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## LEAD FRAME DESIGN FOR INCREASED CHIP PINOUT

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to integrated circuit modules, and in particular, to modules using lead frames.

#### 2. Description of the Related Art

An integrated circuit (IC) module supports and protects an IC chip, or die, while also providing electrical paths between the IC chip and a host printed circuit board (PCB). As shown in FIG. 1b, an embodiment of a common IC module 100 includes an IC chip 110 mounted on a metal lead frame 120, and encapsulated by a ceramic or plastic preformed casing 130. An electrical interface between IC module 100 and a host PCB is provided by multiple IC-PCB interconnections available at the exterior surface of casing 130. Lead frame 120 provides power and signal distribution for IC chip 110, while casing 130 protects IC chip 110 from hostile environments. IC-PCB interconnections can be provided in various ways. For surface mount packages, pins 140 formed directly from lead frame 120 are commonly used. Alternatively, as described in U.S. Pat. No. 5,663,593, issued Sep. 2, 1997 to Mostafazadeh et al., a lead frame ball grid array (BGA) package includes solder balls 150 that provide the IC-PCB interconnections, as shown in FIG. 1c. Other conventional techniques include pin-through-hole technology and lead-less chip carriers.

Lead frame 120, etched or stamped as a single unit from a thin metal sheet or strip, includes a central die attach platform 121 surrounded by narrow leads 122, rigidly maintained by a skirt 123, as shown in FIG. 1a. IC chip 110 mounted on the top surface of platform 121 includes a plurality of input/output (I/O) pads which must be electrically connected to the PCB in order for IC chip 110 to function properly. The I/O pads include power and ground I/O pads to provide power to IC chip 110, and signal I/O pads for data and control signal communications. The I/O pads are wire bonded to leads 122, typically with fine-diameter gold wires 114. After the assembly formed by lead frame 120, IC chip 110, and wires 114 is encapsulated by casing 130, skirt 123 is removed by trimming, and the desired number of pins 140 are created, as shown in FIG. 1b. FIG. 1c depicts an embodiment of a conventional lead frame BGA package. Rather than multiple pins 140, at each interconnection location, a solder ball 150 is installed. In a lead frame BGA package, encapsulant material is typically dispensed over the top surface of the assembly formed by lead frame 120, IC chip 110, and wires 114 and then molded into a casing 160, although a preformed cap is sometimes used. A mask 170 on the bottom surface of lead frame 120 includes openings, or vias, through which solder balls 150 are attached to lead frame 120. Optional solder balls 150 on the bottom surface of platform 121 can be used to provide supplemental heat dissipation for IC chip 110. Mask 170 can be formed using a solder mask, selective plating, or even patterned polyamide tape. Ideally, mask 170 would provide circular vias in order to ensure a uniform height and profile for all solder balls 150 applied to lead frame 120. However, because of the difficulties associated with defining a circular area in a narrow region, rectangular vias are typically provided for leads 122. As a result, height variations can occur among the installed solder balls 150 on leads 120, as the extent to which solder flow will occur into the corners of the rectangular vias is inconsistent and unpredictable. The height variations can ultimately lead to poor electrical

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contact with the host PCB. It is therefore desirable to provide a method for producing circular vias for the leads of a lead frame BGA package.

The allowable number of IC-PCB interconnections, or module pinout, is defined by standard module interface requirements, either through explicit module pinout specification or restrictions on interface area. Therefore, in a conventional IC module where each I/O pad of the IC chip is coupled to a unique one of the IC-PCB interconnections, the allowable number of I/O pads, or chip pinout, is restricted by the module pinout. This is the case even when multiple I/O pads require the same interface signal. For example, if IC chip 110 shown in FIG. 1b includes two power I/O pads, each would require a separate IC-PCB interconnection, depleting the number of interconnections available for signal I/O pads. Similarly, redundant ground I/O pads would occupy additional IC-PCB interconnections, despite being coupled to the same electrical potential. Although some IC module designs connect multiple pads to a single IC-PCB interconnection, this is typically not done because I/O pads requiring a common signal are generally not located in close proximity, making wire bonding to a common interconnection difficult.

Accordingly, it is desirable to provide a module design that maximizes chip pinout without increasing module pinout.

### SUMMARY OF THE INVENTION

The present invention provides a lead frame design for taking advantage of redundant signal requirements, including redundant power supply voltage or ground potential requirements, to increase the allowable chip pinout for a given module pinout.

An embodiment of the present invention includes bus bars that provide a common connection area for shared power, ground, or communications signals. By connecting all I/O pads on an IC chip requiring a common input to a single bus bar, multiple I/O pads can be serviced by a single IC-PCB interconnection. The present invention can be used in any IC module type using a lead frame, including dual in-line packages (DIP), quad flat packs, plastic leaded chip carriers (PLCC), and lead frame BGA packages. The bus bars are incorporated into the lead frame using conventional lead frame manufacturing processes without substantial increase in lead frame complexity or cost.

Additionally, an embodiment of the present invention provides a lead frame having circular attachment pads for solder balls at the end of all leads. The attachment pads eliminate the need for circular vias while ensuring consistent solder profile creation during solder ball installation.

The present invention will be better understood upon consideration of the accompanying drawings and the detailed description below.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. 1a-1c show a conventional lead frame design incorporated into an IC module;

FIGS. 2a-2b show an embodiment of the present invention incorporated into a pin-type IC module; and

FIGS. 2c-2d show an embodiment of the present invention incorporated into a lead frame BGA IC module.

Use of the same reference number in different figures indicates similar or like elements.

### DETAILED DESCRIPTION

The present invention increases the allowable chip pinout of an IC chip for a given IC module that uses a lead frame